non-speech signals, no dramatic improvement in reversals was found with individualized HRTFs. The fact that individualized HRTFs did not significantly increase azimuthal accuracy was not surprising given the spectral characteristics of speech.

The results taken as a whole suggest that a complete, high-fidelity emulation of all free-field sound characteristics is not required for an effective spatialized auditory display.

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Bioelectric Keyboard and Joystick for Computer Control
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The shrinking size of personal computer systems now makes it possible to wear a functional computer with display goggles available for visualization, but data entry requires the use of keyboards and mice. Our work has focused on eliminating keyboards and joysticks by monitoring the electrical activity in the muscles known as Electromyograms (EMG). We have created software that translates the EMG signals into computer commands such as keystrokes and joystick movement. This software works in a way similar to speech recognition. When a gesture from a fixed set of gestures is performed, the resulting EMG signals are recognized and the computer command corresponding to that gesture is issued to the computer.

We have demonstrated two uses of this technology. The first demonstration involved using the virtual joystick interface to control a class IV flight simulation to land a 757 transport aircraft at San Francisco airport. This activity represents coarser grained movements. The acting pilot reached into the air, pretended to hold and manipulate a joystick. Four movements were used: banking to the left, banking to the right, pitching up, and pitching down. These gestures could be held for an arbitrary amount of time so that rolls could be performed. The strength of the gesture was translated into the rate of the banking and pitching movements.

To demonstrate finer grained gestures we measured finger movements involved in pretending to type on a number pad. We then were able to "type" on the surface of a table and even on our pants. Figure 1 depicts typing on the participant's knee as if it were a numerical keypad, the resulting numbers are shown on the screen.

This technology was demonstrated using movements similar to those that computer users are familiar with from day to day such as
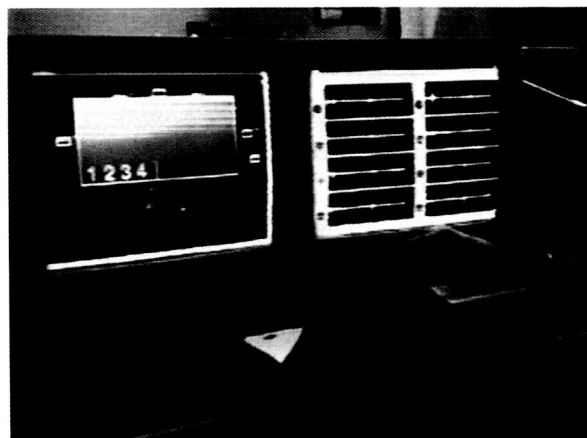

Fig. 1. Demonstration of bioelectric keypad using wet electrodes. The left computer screen shows the recognized keystrokes, the right screen shows the raw EMG signals.

typing and moving joysticks. Obviously the ideal interface should evolve away from the qwerty keyboard and into one that is more natural and incorporates speech recognition. However speech alone is not adequate. For example consider rotating and zooming a three dimensional complex object, or numerical entry applications such as inventory. In particular we are focusing on applications specific to NASA such as being able to perform data entry while constrained by a space suit, controlling remote robotics, and focusing on wearable computing applications.

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Center for Turbulence Research: 2000 Summer Program

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A volume of research reports of the Center for Turbulence Research (CTR) Summer Program has been published. The eighth Summer Program of the CTR took place in the 4-week period, 2 July to 27 July 2000. This was the largest CTR Summer Program to date, involving 40 participants from the United States and nine other countries. Twenty-five Stanford and NASA Ames staff members facilitated and contributed to most of the Summer projects.

Several new topical groups were formed, which reflects a broadening of the CTR's interests from conventional studies of turbulence to the use of turbulence analysis tools in applications such as optimization, nanofluidics, biology, and astrophysical and geophysical flows. The CTR's main role continues to be in providing a forum for the study of turbulence and other multiscale phenomena for engineering analysis. The effect of the Summer Program in facilitating intellectual exchange among leading researchers in turbulence and closely related flow-physics fields is clearly reflected in the proceedings.

The development of the dynamic procedure at the CTR has continued to generate renewed interest in large-eddy simulation (LES) over the past decade. During the Program, new averaging strategies, new equations, and decompositions of the flow field using wavelets were evaluated and tested. In addition, efforts continued in modeling the near-wall turbulence, which remains a pacing item, and in evaluating LES in predicting flow-generated noise. The combustion group continued to attract researchers from around the world. Work on the development and assessment of combustion models was supplemented this year by a large effort to evaluate the use of LES in industrial applications.

The Reynolds-averaged Navier-Stokes (RANS) modeling group continued its effort in developing models that capture the effects of rotation and stratification on turbulence. The ability of RANS models to predict transition was also evaluated. The program benefited from the infusion of novel new ideas from deterministic and stochastic optimization for flow control. These ideas were tested in optimizing microfluidic channels (fig. 1). A novel application of these optimization techniques was the use of evolutionary algorithms in developing strategies for the destruction of aircraft trailing vortices.

The astrophysical group concentrated on protoplanetary disk modeling and simulation. New ideas and transformations of the governing equation promise new advances in this field in the near future. The geophysics group used direct numerical simulation to study sediment